

First Fossil Species of the Chemosynthetic-Community Gastropod *Provanna*: Localized Cold-Seep Limestones in Upper Eocene and Oligocene Rocks, Washington

by

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Abstract. The only known fossil species of the chemosynthetic-community gastropod *Provanna* is named and described from four localized Eocene and Oligocene cold-seep limestones in western Washington. The new species, *Provanna antiqua*, is present in the upper Eocene Bear River deposit near the mouth of the Columbia River, in the lower Oligocene Makah Formation at both Shipwreck Point and near Neah Bay on the northern Olympic Peninsula, and in the upper Oligocene part of the Lincoln Creek Formation at Canyon River in southwestern Washington. The deep-sea limestones at these localities contain dense concentrations of macrobenthos that lived in association with subduction-related cold-methane seeps.

Provanna antiqua shows a great range in shell morphology, from smooth to moderately sculptured to cancellate, and there can be as much variation on a single specimen from whorl to whorl as in the whole material. The morphologic variation of the new species is very similar to that in specimens of modern *P. variabilis*.

INTRODUCTION

Most modern species of the gastropod genus *Provanna* Dall, 1918, are associated with chemosynthetic, sulphide-rich environments of the deep sea where there is hydrothermal activity or hydrocarbon seepage (Warén & Ponder, 1991; Lutz, 1991-1992; Tunnicliffe, 1992). At each chemosynthetic biotope, *Provanna* is usually represented by one or two species (Warén & Bouchet, 1993). Recently, the first fossil occurrence of *Provanna* was reported by Goedert & Campbell (1995) who discovered specimens in a cold-methane-seep community of early Oligocene age in Washington. The purpose of this paper is to describe and name this fossil species of *Provanna*. In addition, three other localities for this new species are reported from other cold-methane-seep chemosynthetic communities in localized limestones in lower Tertiary rocks in Washington.

Abbreviation used for catalog and/or locality numbers is: LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.

STRATIGRAPHIC DISTRIBUTION AND GEOLOGIC AGES

Goedert & Campbell (1995) reported morphologically variable specimens of *Provanna* sp. in a cold-seep limestone block at LACMIP loc. 15911 in the Makah Formation at Shipwreck Point, northern Olympic Peninsula, Washington (Figure 1). The Makah Formation was most likely deposited in a bathyal, submarine-fan setting (Snively et al., 1980). The Jansen Creek Member of the Makah Formation is only about 30 m below the limestone block. This member is a transported olistostromal unit containing mostly shallow-water marine conglomerate and fossiliferous sandstone that slid into the basin in which the Makah Formation was being deposited and became enclosed in deep-water (1000 to 2000 m) marine siltstone sandstone (Snively et al., 1980; Kaler, 1988). Goedert & Campbell (1995) concluded that the limestone block at Shipwreck Point is also allochthonous. The limestone is about one meter thick and is highly fossiliferous with randomly ori-

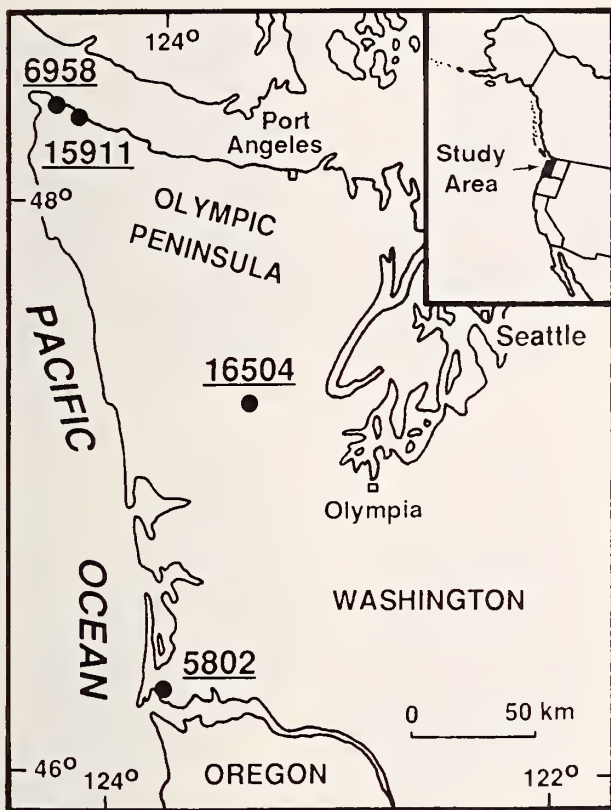


Figure 1

Index map to localities of *Provanna antiqua* Squires, sp. nov.

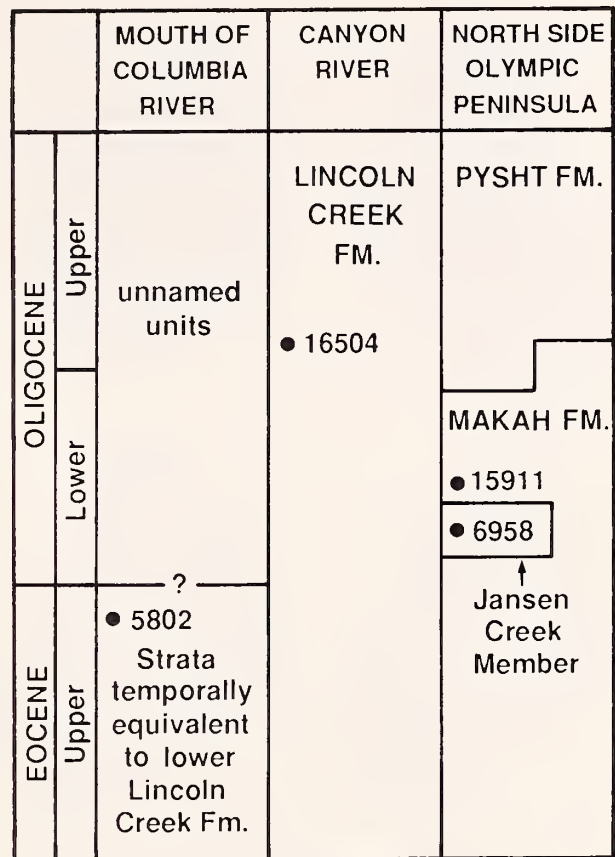


Figure 2

Chronostratigraphic chart showing position of localities for *Provanna antiqua* Squires, sp. nov.

ented specimens that are, in places, closely packed together. They reported that the bivalves (*Modiolus (Modiolus) willapaensis* Squires & Goedert, 1991, and *Calyptogena chinookensis* Squires & Goedert, 1991 are abundant and are associated with vestimentiferan(?) worm tubes, chiton plates, scaphopods, many archaeogastropods and other gastropods, other bivalves, crustacean fragments, and wood fragments. The limestone is enclosed in siltstone barren of megafossils. The portion of the Makah Formation that lies stratigraphically just above the Jansen Creek Member is early Oligocene in age (Figure 2) (Armentrout et al., 1983; Hull et al., 1988). Squires & Goedert (1994) also reported an early Oligocene age for this formation in the vicinity of Shipwreck Point.

Approximately 200 kg of limestone was collected by J. L. Goedert at the Shipwreck Point locality. Most is very hard micritic limestone, and the extraction of fossils is difficult. For some specimens, shell material adheres to the matrix and leaves only internal molds for study. Fifty-six specimens of *Provanna* were found, and 47 (84%) have their shell material intact. The only species of *Provanna* at this locality is *Provanna antiqua*, and it shows much morphologic variation.

Recent fieldwork by J. L. Goedert has yielded another

locality in the Jansen Creek Member of the Makah Formation, northern Olympic Peninsula, where *Provanna antiqua* is present. A single specimen of the new species was found at LACMIP loc. 6958 (Figure 1) in an undescribed cold-seep limestone in the lower Oligocene Jansen Creek Member of the Makah Formation (Figure 2).

Additional fieldwork by J. L. Goedert has yielded a third locality where specimens of *Provanna antiqua* are present. Numerous specimens were found at LACMIP loc. 5802 in a localized limestone temporally equivalent to the lower part of the Lincoln Creek Formation at Bear River, near the mouth of the Columbia River, southwestern Washington (Figures 1, 2). The limestone was deposited in a subduction zone where subsurface methane-rich waters discharged onto the ocean floor (Goedert & Squires, 1990). The limestone, which is exposed in an abandoned quarry, is 15 m thick, 68 m in length, and 38 m wide. It is highly fossiliferous with dense concentrations of the bivalves *Modiolus willapaensis* and *Calyptogena chinookensis*. Other fossils are siliceous sponges, serpulid and vestimentiferan(?) worm tubes, scaphopods, archaeogas-

tropods and other gastropods, other bivalves, crustacean parts, wood fragments, and fish bone. Bivalves are articulated and show growth series (Goedert & Squires, 1990). Several of the molluscan species were named and described by Squires & Goedert (1991). The surrounding rock is deep-water siltstone with few megafossils. The limestone is late Eocene in age (Zone CP15b of Okada & Bukry, 1980) based on calcareous nannofossils and benthic foraminifera (Goedert & Squires, 1990).

Extraction of fossils from the limestone at the Bear River locality is more difficult than that for the limestone in the Makah Formation at Shipwreck Point. One hundred and sixty-four specimens of *Provanna antiqua* were found at the Bear River locality, but only 41 (25%) of these had their shell material intact.

Recent fieldwork by J. L. and G. H. Goedert and K. L. Kaler has yielded a fourth locality where specimens of *Provanna antiqua* are present. Numerous specimens were found at LACMIP loc. 16504 in a small cold-methane-seep limestone block in the upper part of the Lincoln Creek Formation at Canyon River, in the Satsop River area, Grays Harbor County, southwestern Washington (Figure 1). The limestone contains numerous specimens of *Provanna antiqua* and a diverse chemosynthetic community. The surrounding rock is sparsely fossiliferous siltstone containing cold-methane-seep limestones with bivalves (*Acharax* sp. and *Thyasira* sp.) (J. L. Goedert, personal communication). These cold-seep limestones are under study by J. L. Goedert and K. L. Kaler. The limestone at LACMIP loc. 16504 is in the vicinity of benthic foraminifera localities F 107 to 110 of Rau (1966) and mollusk localities CR 39–44 of Armentrout (1973). Both of these workers assigned the rocks at their respective localities to the upper Oligocene (= *Echinophoria apta* Molluscan Zone of Durham, 1944). Moore (1963) subsequently assigned the gastropod *E. apta* to genus *Liracassis*. Specimens of a stratigraphically lowest morph of *Liracassis apta* (Tegland, 1931) were found a short stratigraphic distance downsection from LACMIP loc. 16504 (Armentrout, 1973:pl. 6, fig. 10; J. L. Goedert, personal communication), and it is concluded that the rocks at LACMIP loc. 16504 are earliest late Oligocene in age.

The specimens of *Provanna antiqua* at LACMIP loc.

16504 are the best preserved of this species. Many specimens could be completely freed from the matrix. Ninety-six specimens were found, and nearly all have their shell material intact.

SYSTEMATIC PALEONTOLOGY

Class Gastropoda Cuvier, 1797

Subclass Prosobranchia Milne-Edwards, 1848

Order Caenogastropoda Cox, 1960

Superfamily LOXONEMATOIDEA Koken, 1889

Family PROVANNIDAE Warén & Ponder, 1991

Discussion: In this report, the higher systematics of this family follow that of Warén & Bouchet (1993).

Genus *Provanna* Dall, 1918

Type species: ? *Trichotropis (Provanna) lomana* Dall, 1918, by monotypy, Recent, off Point Loma at 1183 m depth, San Diego, California.

Discussion: There are currently four genera, including *Provanna*, recognized in the family Provannidae; they are reviewed in Warén & Bouchet (1993). Wenz (1940) reported that *Provanna* is confined to the Recent. There are at least 13 living species of *Provanna*, and most of these are illustrated by Warén & Bouchet (1986) or by Warén & Ponder (1991). Shells of the remaining species are illustrated by Warén & Bouchet (1989), Okutani (1990), or Warén & Bouchet (1993). The latter workers assigned one of Okutani's species of *Provanna* to genus *Desbruyeresia* Warén & Bouchet, 1993.

Provanna antiqua Squires, sp. nov.

(Figures 3–18)

Provanna n. sp. Goedert & Campbell, 1995, figs. 4–7.

Diagnosis: A species of *Provanna* with highly variable sculpture ranging from nearly smooth to moderately cancellate. Whorls with a tabulate shoulder delineated by a spiral rib that is sometimes noded.

Explanation of Figures 3 to 18

All specimens coated with ammonium chloride. Unless otherwise indicated figures are approximately $\times 9$ and from LACMIP loc. 16504, upper part of the Lincoln Creek Formation, Canyon River, Washington.

Figures 3–18. *Provanna antiqua* Squires, sp. nov. Figures 3, 4. Paratype LACMIP 12300. Figure 3. Apertural view. Figure 4. Back view. Figure 5. Paratype LACMIP 12301, back view. Figures 6, 7. Paratype LACMIP 12302. Figure 6. Apertural view. Figure 7. Back view. Figure 8. Paratype LACMIP 12303, back

view, $\times 8.3$. Figure 9. Paratype LACMIP 12304, back view showing mineral coatings, $\times 11$. Figures 10, 11. Holotype LACMIP 12299. Figure 10. Back view. Figure 11. Right view. Figures 12, 13. Paratype LACMIP 12305. Figure 12. Apertural view. Figure 13. Back view. Figure 14. Paratype LACMIP 12306, apertural view. Figure 15. Paratype LACMIP 12307, back view. Figure 16. Paratype LACMIP 12308, back view. Figure 17. Paratype LACMIP 12309, right view, $\times 9.6$. Figure 18. Paratype LACMIP 12315 from LACMIP loc. 15911, lower Makah Formation at Shipwreck Point, back view, $\times 8.3$.



3



4



5



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7



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10



11



12



13



14



15



16



17



18

Table 1

Measurements (mm) of *Provanna antiqua* Squires, sp. nov.

LACMIP catalog no.	H	W
12299	5.6	4.2
12300	5.4	3.9
12301	5.3	3.7
12302	5.8	4.1
12303	5.7	4.2
12304	4.5	3.3
12305	5.1	4.2
12306	5.4	4.6*
12307	5.1	4.2
12308	5.4	4.0
12309	5.3	3.7
12315	5.7	4.5

H = height; W = width. * = crushed.

Description: Shell small, up to 6 mm high, ovate fusiform. Spire elevated, approximately one-third of height of shell. Suture distinct. Body whorl moderately globose with distinct neck having one or more spiral ribs (usually weak). Whorls usually with a tabulate shoulder delineated by a spiral rib that can be noded. Whorls vary from nearly smooth (with only very weak spiral ribs or very weak axial riblets formed by rugose growth lines), to moderately sculptured (with several spiral ribs, widely but evenly spaced) to moderately cancellate (with small nodes at intersections of weak axial riblets and the stronger spiral ribs). Spiral ribs on penultimate whorl vary from zero to four; spiral ribs on body whorl vary from two (one on the shoulder and one on the neck) to approximately seven, with increasing strength toward the base. Axial riblets vary from zero to approximately 19, with minute nodes especially prominent on tabulate shoulder. Axial riblets only on posterior half of body whorl.

Holotype: LACMIP 12299.

Type locality: LACMIP 16504, upper part of the Lincoln Creek Formation, latitude 47°16'42"N, longitude 123°31'19"W.

Paratypes: LACMIP 12300 to 12309, all from LACMIP loc. 16504; and LACMIP 12315 from LACMIP loc. 15911.

Dimensions: See Table 1.

Discussion: A total of 317 specimens of the new species were found. None has the protoconch preserved. These specimens have two or three teleoconch whorls and are approximately 5 to 6 mm in height. Only 182 specimens (57%) have their shell material intact. These particular specimens show a great range in morphology, with 58% entirely smooth or smoothish, 4% axially ribbed on the body whorl shoulder, 18% spirally ribbed on one or more

whorls, and 20% cancellate on one or more whorls. There is a complete gradation from one type of morphologic form to the next, and the gradation does not follow any pattern. On the holotype (Figures 10, 11) for example, the antepenultimate whorl has only the characteristic spiral rib on the shoulder and two other very faint spiral ribs far anteriorly. The penultimate whorl has five strong spiral ribs (with the one on the shoulder noded), crossed by very low axial riblets that produce a weak cancellate sculpture. The body whorl, however, is essentially smooth with only faint spiral ribs.

At the Bear River locality (LACMIP loc. 5802) and the Canyon River locality (LACMIP loc. 15604), approximately 70% of the specimens with their shell material intact are smooth or nearly smooth, and the rest have moderate to strong sculpture. At Shipwreck Point (LACMIP loc. 15911), just the opposite was found. There, approximately 75% of the specimens with their shell material intact have moderate to strong sculpture, and the rest are smooth or nearly smooth.

A few specimens of the new species were found coated with calcareous deposits. An example is shown in Figure 9.

When compared to the other species of *Provanna*, the considerable morphologic variability of the shell of *P. antiqua* is most like *P. variabilis* Warén & Bouchet (1986: 163–164, figs. 10, 11, 13–15), a living species from the Juan de Fuca Ridge off the coast of Washington. *Provanna variabilis*, much like the new species, varies from nearly smooth (with only a few spiral ribs) to strongly spirally ribbed to cancellate, and there can be almost as much variation of the sculpture along the spire of a single specimen as in the whole material. The new species differs by having tabulate whorls, more axial and spiral ribs, and much more closely spaced ribbing.

According to Warén & Bouchet (1993), *Provanna* is usually represented by one or two species at each chemosynthetic biotope, but few of them have been recorded from more than one site. The presence of *Provanna antiqua* at four localities that are geographically and stratigraphically distinct is especially noteworthy. Warén & Bouchet (1993) also mentioned that modern species of *Provanna* are commonly highly variable in shell morphology. This is certainly true for *Provanna antiqua*. If a large number of specimens of *Provanna antiqua* had not been collected, the wide variation in morphology within this species would undoubtedly be misinterpreted, and two or more species would be "recognized."

Etymology: The specific name is derived from *antiquus*, Latin, meaning old or ancient.

Occurrence: Late Eocene and early Oligocene, western Washington. LATE EOCENE: Strata temporally equivalent to the lower part of the Lincoln Creek Formation, Bear River area near mouth of Columbia River, Washington. EARLY OLIGOCENE: Makah Formation and Jansen Creek Member of the Makah Formation, north

side of Olympic Peninsula, Clallam County, Washington. EARLIEST LATE OLIGOCENE: Upper part of Lincoln Creek Formation, Canyon River, Grays Harbor County, Washington.

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LOCALITIES CITED

LACMIP 5802. In an abandoned quarry on the south side of Bear River, latitude 46°20'N, longitude 123°55'52"W, in the SE¼, SE¼, of sec. 20, T. 10 N, R. 10 W, Chinook U.S. Geological Survey 7.5-minute quadrangle, Pacific County, southwestern Washington. Strata temporally equivalent to the lower part of the Lincoln Creek Formation. Age: Late Eocene. Collector: J. L. Goedert, 1993.

LACMIP 6958. Approximately 1 km SE of mouth of Bullman Creek, on beach terrace W½ of SW¼ of sec. 21, T. 33 N, R. 14 W, Cape Flattery U.S. Geological Survey quadrangle, 15-minute, 1957, Clallam County, Washington. Jansen Creek Member of the Makah Formation. Age: Early Oligocene. Collectors: W. Buchanan & J. L. Goedert, 1984 to date.

LACMIP 15911. Limestone block within thin-bedded sandstone and siltstone deposits, accessible only at low tide, at Shipwreck Point, latitude 48°19'N, longitude 124°26'45"W, SE¼ of NE¼ of sec. 36, T. 33 N, R. 14 W, Sekiu River U.S. Geological Survey quadrangle, 7.5-minute, provisional edition 1984, Clallam County, Washington. About 30 m stratigraphically above top of Jansen Creek Member of the Makah Formation. Age: Early Oligocene. Collector: J. L. Goedert, 1991, 1992.

LACMIP 16504. At elevation of 390 ft., limestone block within siltstone on the north side of a sharp bend in Canyon River, latitude 47°16'42"N, longitude 123°31'19"W, 600 m N and 290 m E of SW corner of sec. 25, T. 21 N, R. 7 W, Grisdale U.S. Geological Survey quadrangle, 7.5-minute, 1990 provisional edition, Grays Harbor County, Washington. Upper part of the Lincoln Creek Formation. Age: Earliest late Oli-

gocene. Collectors: J. L. & G. H. Goedert, & K. L. Kaler, 1993.

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